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PHYSICAL AND CHEMICAL PROPERTIES OF LAKE TANGANYIKA.(U)

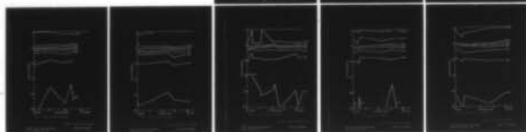
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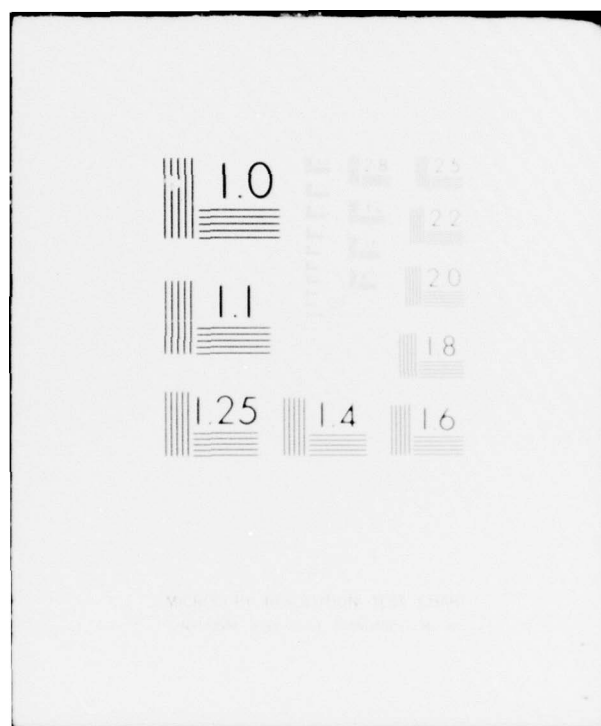
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PHYSICAL AND CHEMICAL PROPERTIES OF LAKE TANGANYIKA

by

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NUSC/NL Technical Memorandum No. 2213-331-70

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INTRODUCTION

Environmental measurements are an important part of any acoustic propagation exercise. They are necessary in designing and interpreting acoustic experiments. Of particular importance is the physical and chemical characterization of the sound medium in bodies of water where only one series of acoustic measurements are planned.

The sound attenuation experiment in Lake Tanganyika during April, 1970, was just such an experiment. Lake Tanganyika was specifically chosen as a test site in order to observe what effect an increase in temperature would have on the low frequency sound attenuation anomaly encountered in the deep ocean.<sup>1,2,3</sup> The low concentration of dissolved salts in the lake water would also allow us to establish whether the sound absorbing phenomenon was dependent on salt concentration.<sup>4</sup>

#### ADMINISTRATIVE INFORMATION

This memorandum was prepared under NUSC/NL Project Title Bottom Environmental Acoustic Characteristics, J. Gallagher and E. Jones, NUSC/NL Principal Investigators. The sponsoring activity was NAVSHIPS Code OCV1, B. Couper, Program Manager.

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During the acoustic test and shortly afterwards, limnological measurements were conducted in the lake in an area that covered a large portion of the sound propagation track (Fig. 1).

This report is restricted to the analysis and preliminary results of the acoustic support data gathered.

## EXPERIMENTAL

Expendable bathythermographic (XBT) measurements were made along the ship's track (Fig. 2) at frequent intervals. Both 1830m and 750m depth XBT probes were used, so that temperature profiles reached the lake bottom in all cases.

Twenty-one hydrographic stations were made on the lake. Most of these were concerned with the joint WHOI/NUSC/NL<sup>5</sup> collection of geophysical data sought by Woods Hole scientists interested in the African rift system. Lake water from a Nansen cast taken in the 1400m southern basin at 07°13'S, 30°14'E and sediment from a gravity core at 07°13'S, 30°16'E were analyzed for soluble chemical species at NUSC/NL. The solid phase of the sediment was also analyzed chemically as well as subjected to X-ray and microscopic inspection. Interstitial solutions were expressed aboard ship from the sediment soon after the core was recovered. The solutions were stored in sealed glass vessels.

## PROCEDURE

Temperature profiles were reduced by the NODC who provided a print-out of depths corresponding to every  $\frac{1}{2}^{\circ}\text{C}$  temperature increment. Surface and bottom temperatures were provided on the same print-out.

Chemical analyses consisted of determining the concentration of sodium, magnesium, calcium, potassium, chloride, iron, and manganese present in (a), the lake water column, (b), the interstitial solutions of the bottom sediments and (c), the solid phase sediment.

The instrumentation employed for all analyses, except the chloride determination, was a Perkin-Elmer model 303 atomic absorption flame spectrophotometer. Lake and interstitial water samples were quantitatively diluted to a concentration suitable for analysis. Concentration

working ranges for atomic absorption spectroscopy were typically 1-10 micrograms per ml for most cations under investigation. The absorption of each unknown was measured and compared to the absorption of solutions of known concentration. Calibration procedures were varied in accordance with the cations and their concentration.

Core samples were first filter-pressed to extract all available water, and then dried completely in an oven for two hours at 115°C. A portion of each of the three samples tested was then fired at 700°C to remove all organic material. A 0.5 sample was weighed out to an accuracy of 0.1 mg then dissolved in a solution of 5 ml HF, 5 ml HNO<sub>3</sub> and 6 ml distilled water. This was done in a graduated vessel so that the solution could be heated slowly until exactly 15 ml of liquid remained. A large portion of insoluble material remained at the bottom flask. The residue, subsequently found to consist of silica, was disregarded during the acid soluble analysis. Aliquots of these solutions were quantitatively diluted to concentrations suitable for analysis.

The chloride determination performed on the lake and interstitial water samples was done by the Volhard method.<sup>6</sup> All samples tested were undiluted, since an appreciable amount of chloride must be present for this method to be effective.

#### RESULTS AND DISCUSSION

Results of the analysis of the lake water samples are expressed in terms of concentration in micrograms per ml and can be found following the text (Fig. 3). They indicate that the concentrations of sodium, potassium, magnesium and chloride remain effectively constant in the water below 100m, while the calcium concentration increases gradually with increasing depth. From surface to 100m, (the extent of the thermocline) potassium, magnesium and sodium all substantially increase in concentration. The chloride curve is more scattered due largely to the errors inherent in the Volhard technique when determining very dilute solutions. The general increase in salt concentration is in agreement with our results of a year before the present observations.<sup>7</sup> The concentrations of iron and manganese were below the detection limit of the instrument; less than 0.5 micrograms per ml.

In the interstitial water analysis the results (Fig. 4) indicate that the concentrations of sodium, magnesium, potassium, and calcium decrease markedly with depth of penetration into the bottom, while the chloride concentration shows a slight tendency to decrease with depth. The concentrations of iron and manganese here, too, were below the instrumental detection limit. It is probable that the salts dissolved in the lake water are not derived from the bottom sediments but rather they enter the lake from rivers like the Ruzizi which flows into the north of Lake Tanganyika from more saline Lake Kivu.

Results of the analysis of the three core samples tested are expressed in terms of percent of dry weight of the fired sample. Table I summarizes these results.

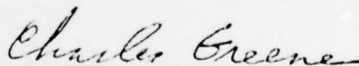
TABLE I						
Sample Depth, cm.	Concentration of cations; % of fired sediment weight					
	K	Na	Mg	Ca	Fe	Mn
0	.029	.024	.022	.079	.093	.006
90	.031	.025	.023	.081	.155	.019
220	.033	.033	.019	.077	.107	.007

The cations which were tested for, comprise less than 1% of the fired sediment weight. Silica makes up nearly all the lake bottom material. However, contrary to the results obtained for the lake and interstitial water samples, these indicate a relatively large percentage of iron and calcium in the solid sediment compared to the percentages of potassium, magnesium, sodium, and manganese present. All percentages remain effectively constant with core depth except for an unexplainable increase in the amount of iron in the middle of the core. X-ray and microscopic inspection verified that the bulk of the bottom sediment consisted of diatom skeletons which accounts for the very high silica percentage.

#### RESULTS AND DISCUSSION OF THERMAL MEASUREMENTS

Half degree isotherms were constructed by plotting the position of each XBT reading taken on a chart of the lake, and assigning each reading to one of several tracks established arbitrarily. Generally, these tracks ran either parallel to the axis of the lake or traversed it at different points. Figure 5 shows the tracks on the lake for the isotherms plotted on Figs. 6-11.

Temperature results show that during April the thermocline occurs at a depth of approximately 50m and remains at a relatively constant depth in the lake. Such behavior should result in an equally uniform sound velocity distribution throughout the lake. A slight depression of the surface isotherms is evident at the southern end of the lake. The surface temperature also increased slightly toward the shores of the lake, as would be expected.



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Chemist



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Chemical Oceanographer



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5. E. N. Jones, R. H. Mellen, D. G. Browning, NSF Prop. Ref. No. A020210-00 DES/Oceanography Section, 1969
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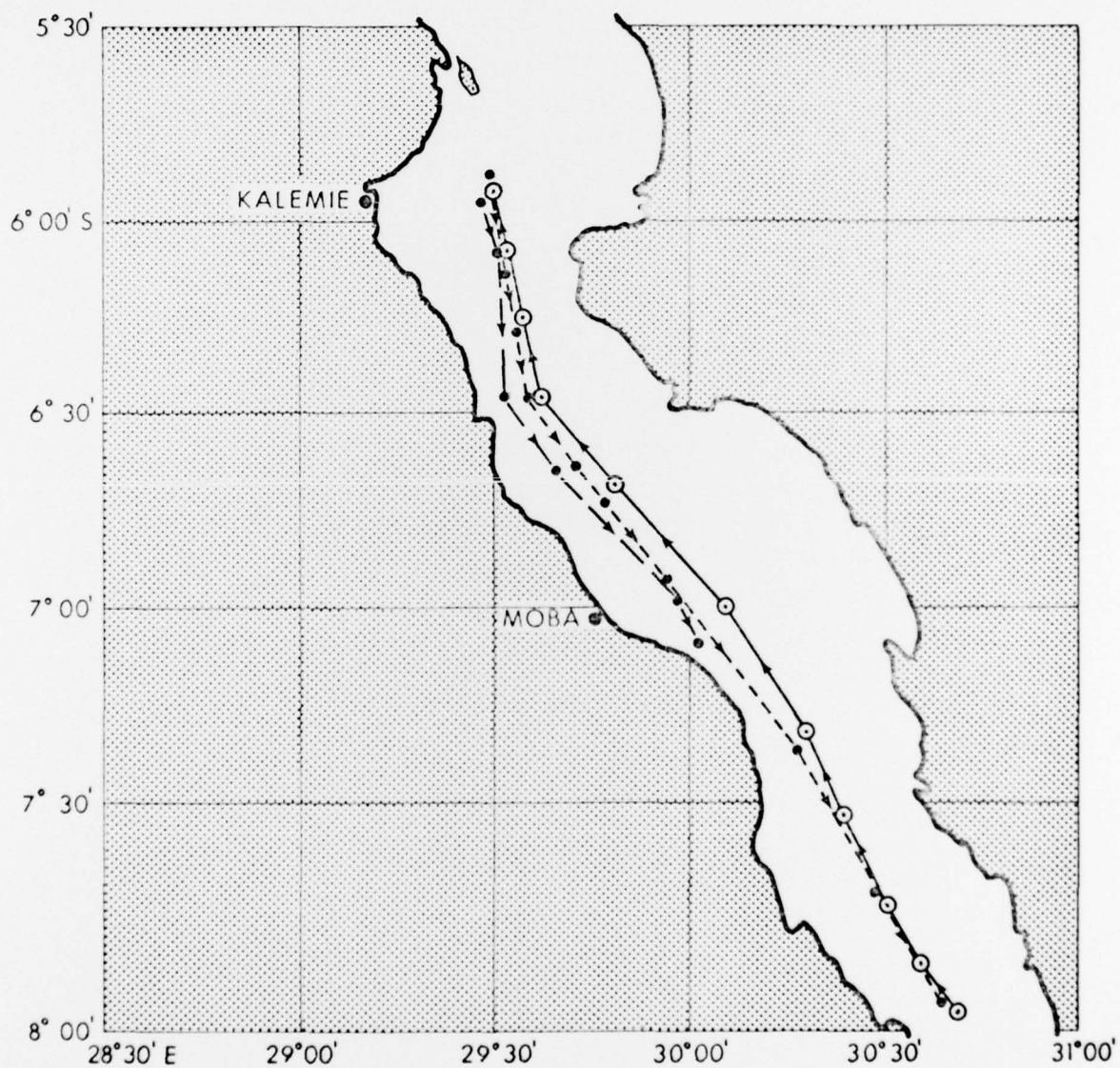


Fig. 1 - Acoustic Propagation Tracks 3, 4, and 5.

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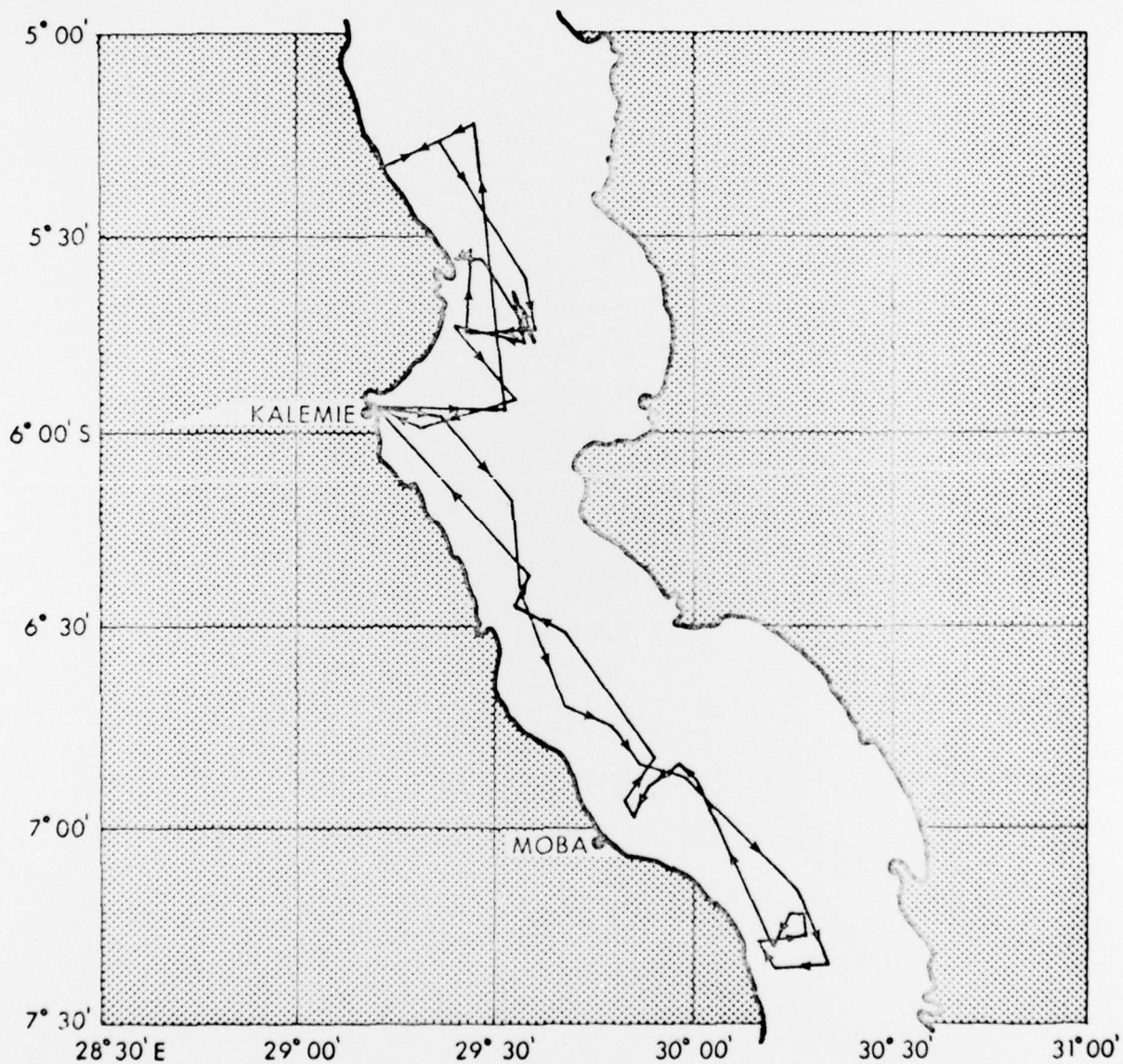


Fig. 2 - Details of Ship's Track.

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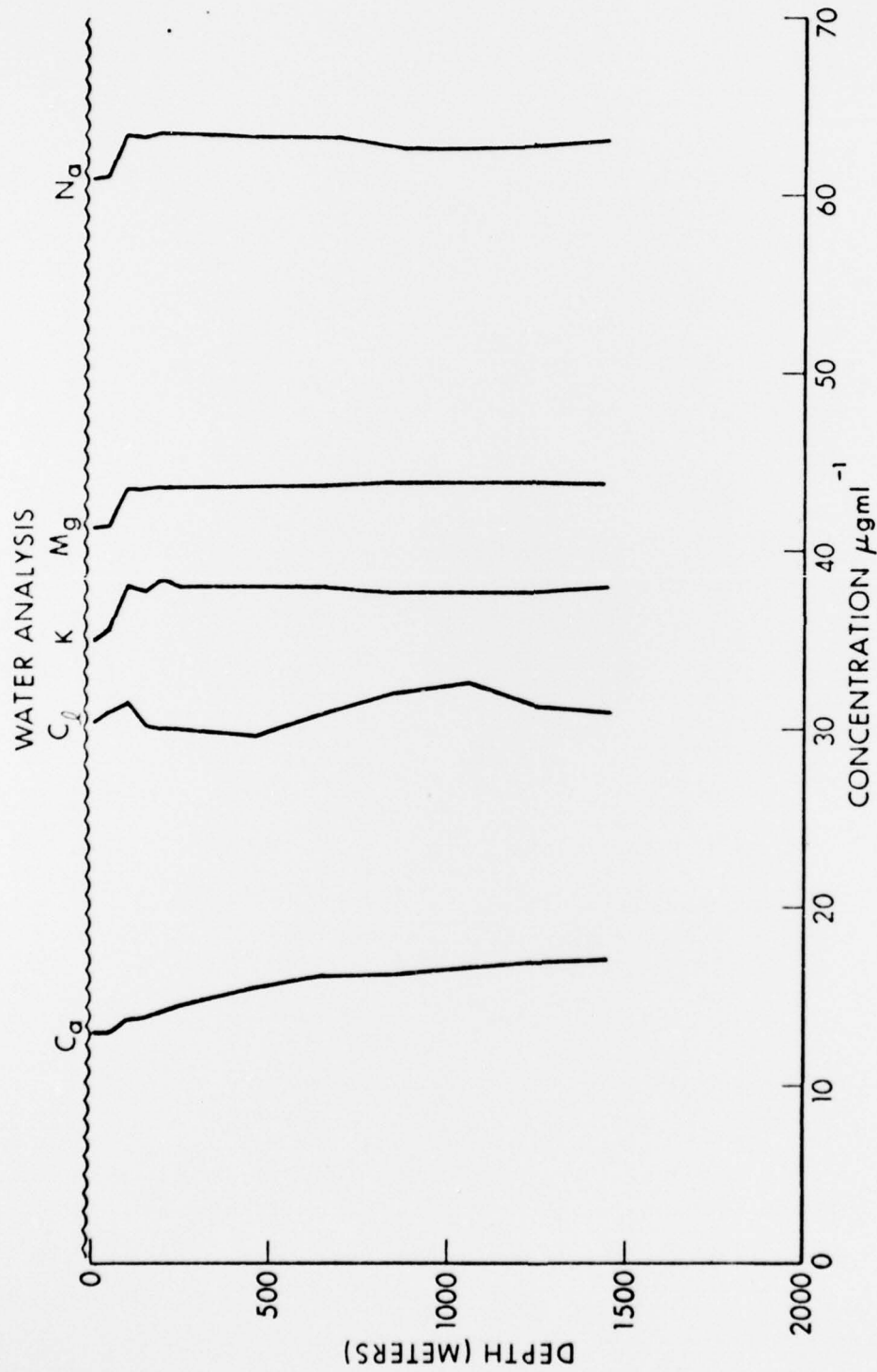


Fig. 3 - Water Column Analysis. Nansen Cast Station 3.

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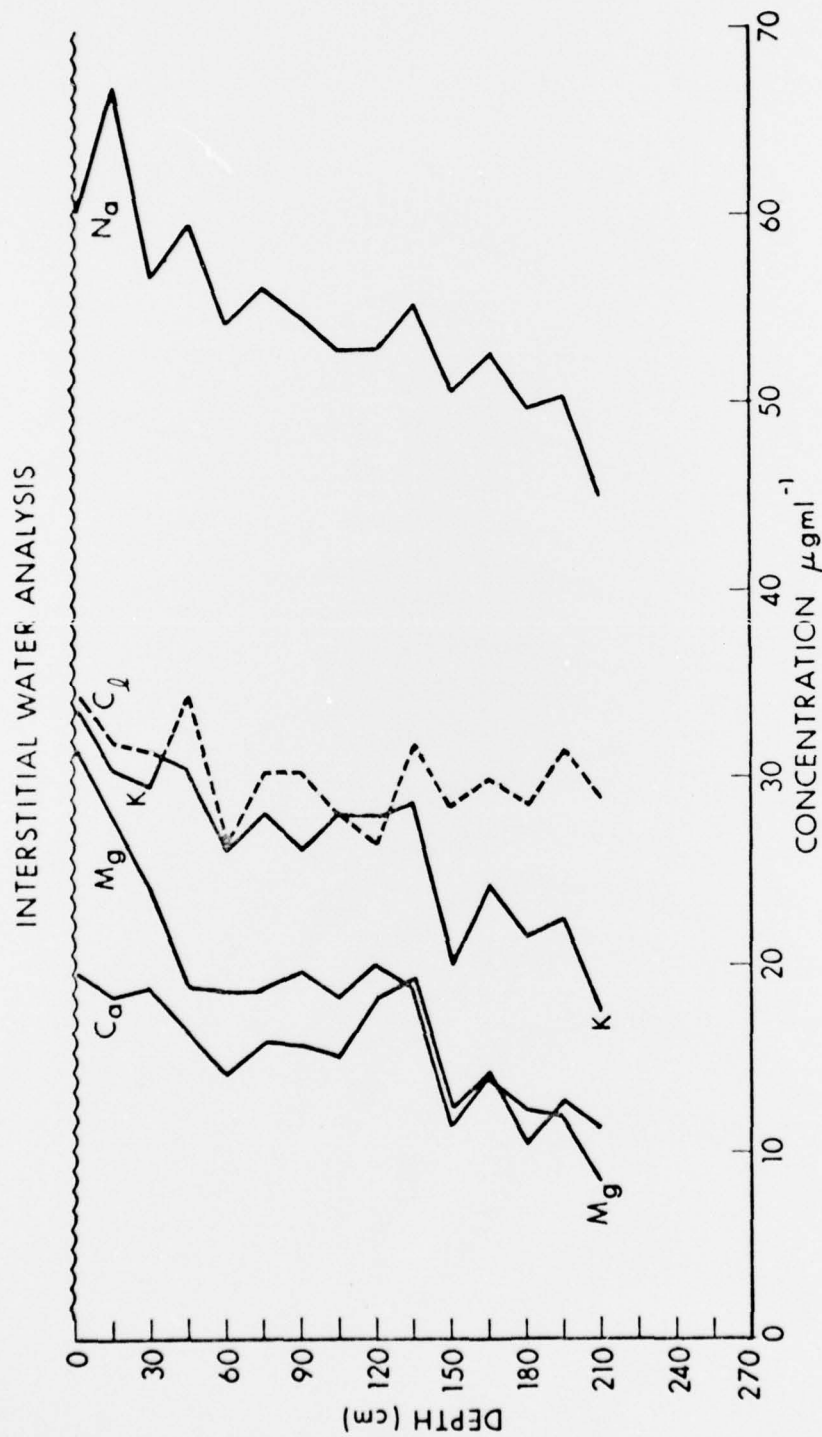


Fig. 4 - Interstitial solution analysis Southern Basin Station 2.

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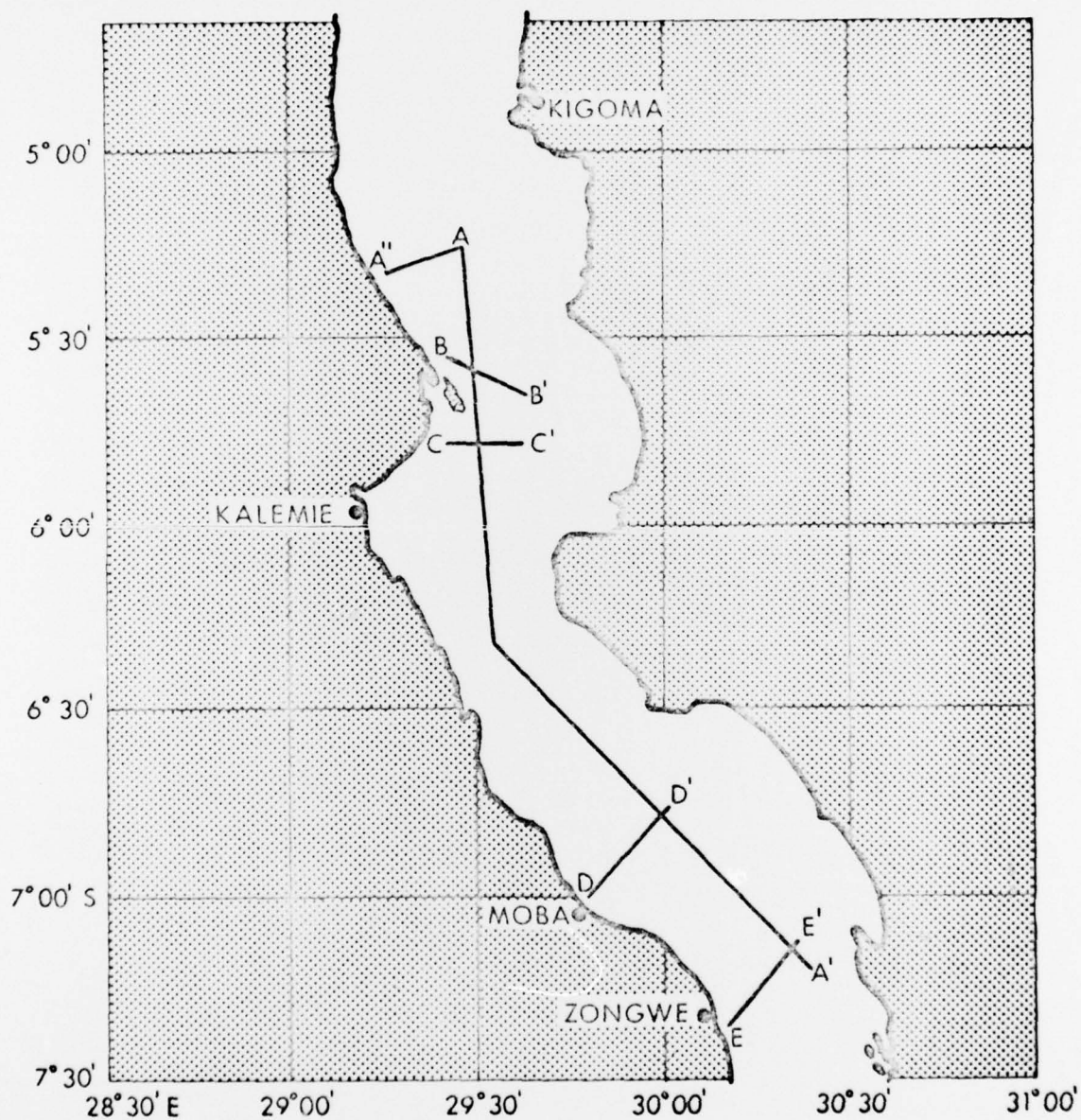


Fig. 5 - Locations of Isotherms. The lowest Temperature Recorded in the Lake was 23.3°C at a Depth of 1364m.

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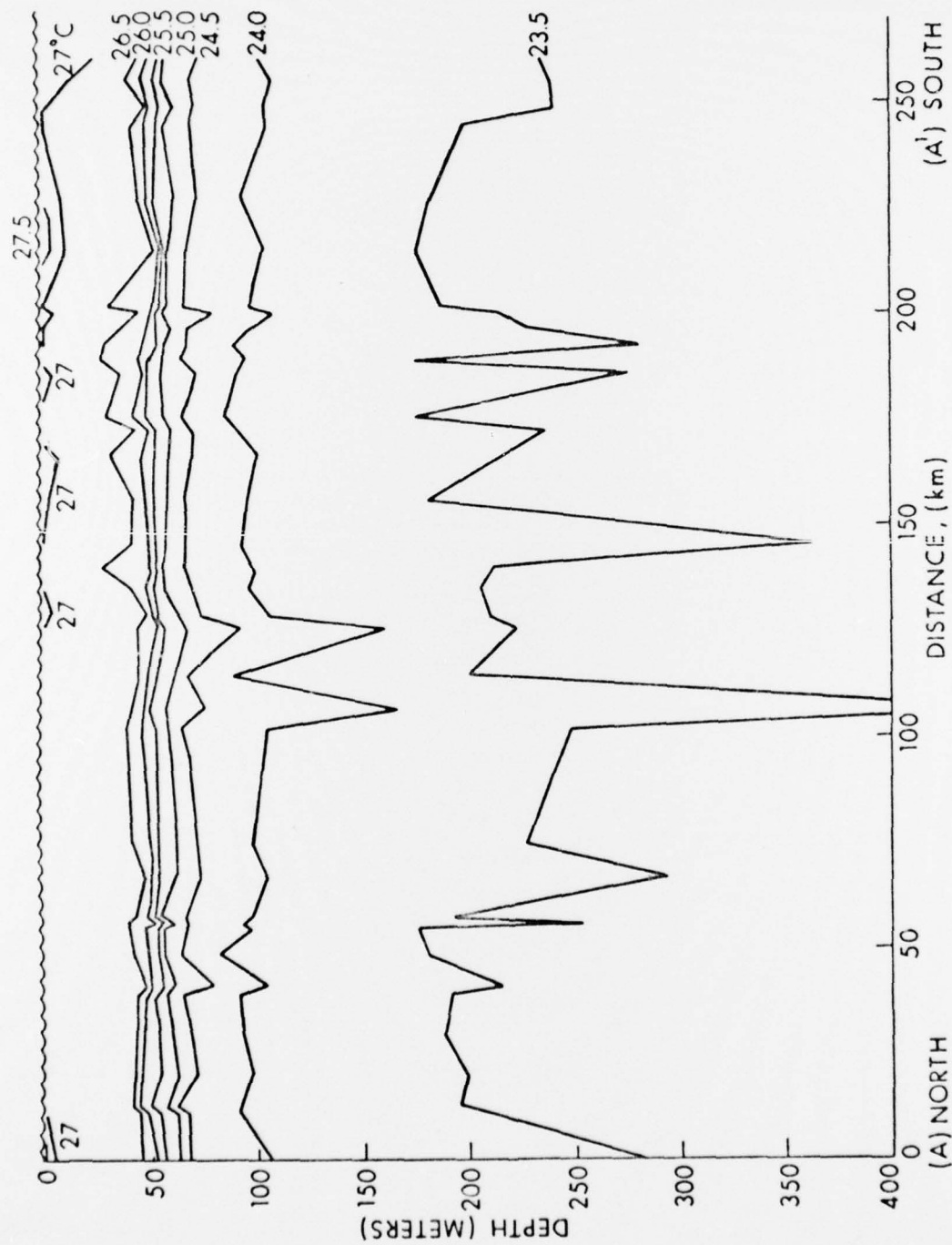


Fig. 6 - Axial Isotherms.

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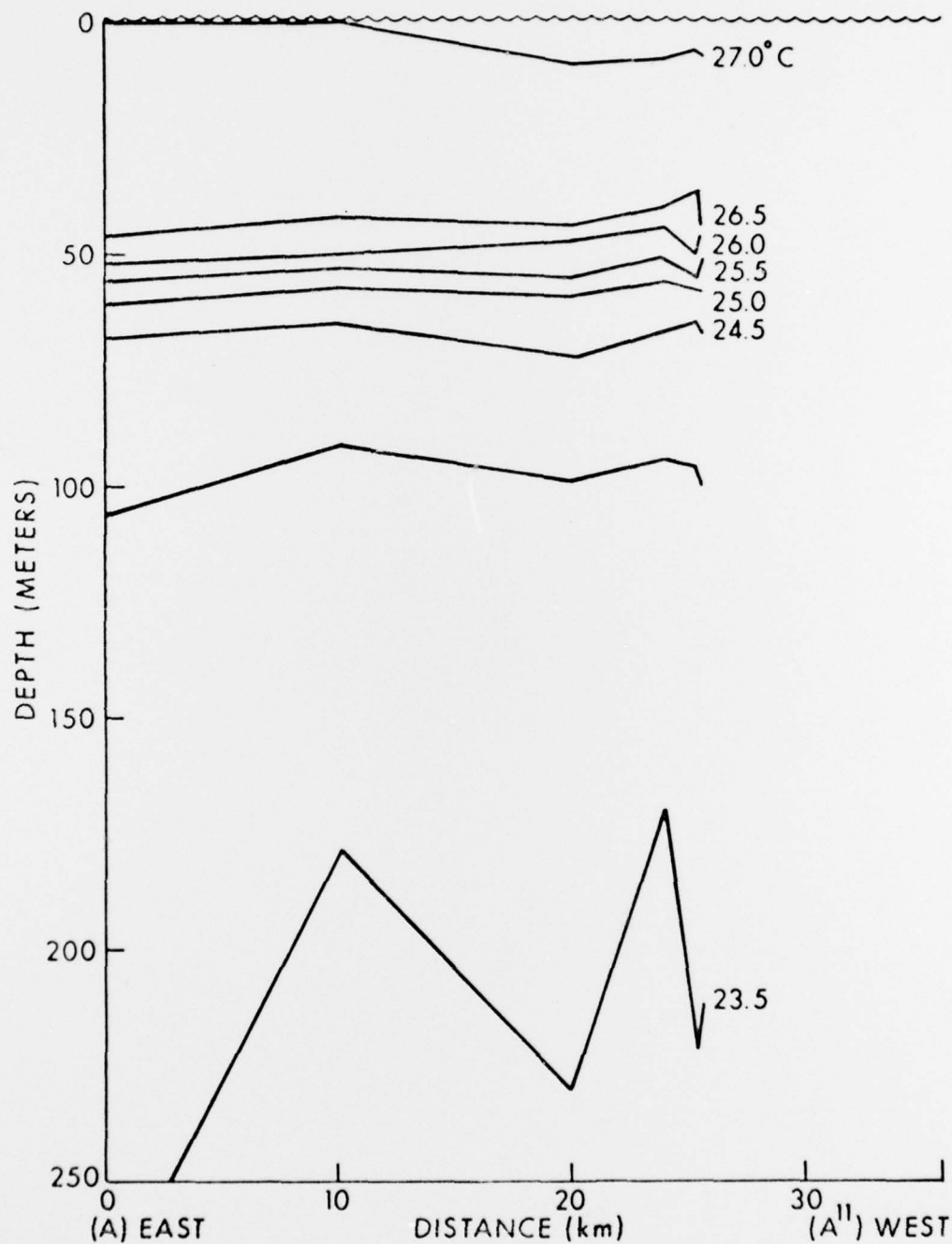


Fig. 7 - Cross-sectional Isotherms.

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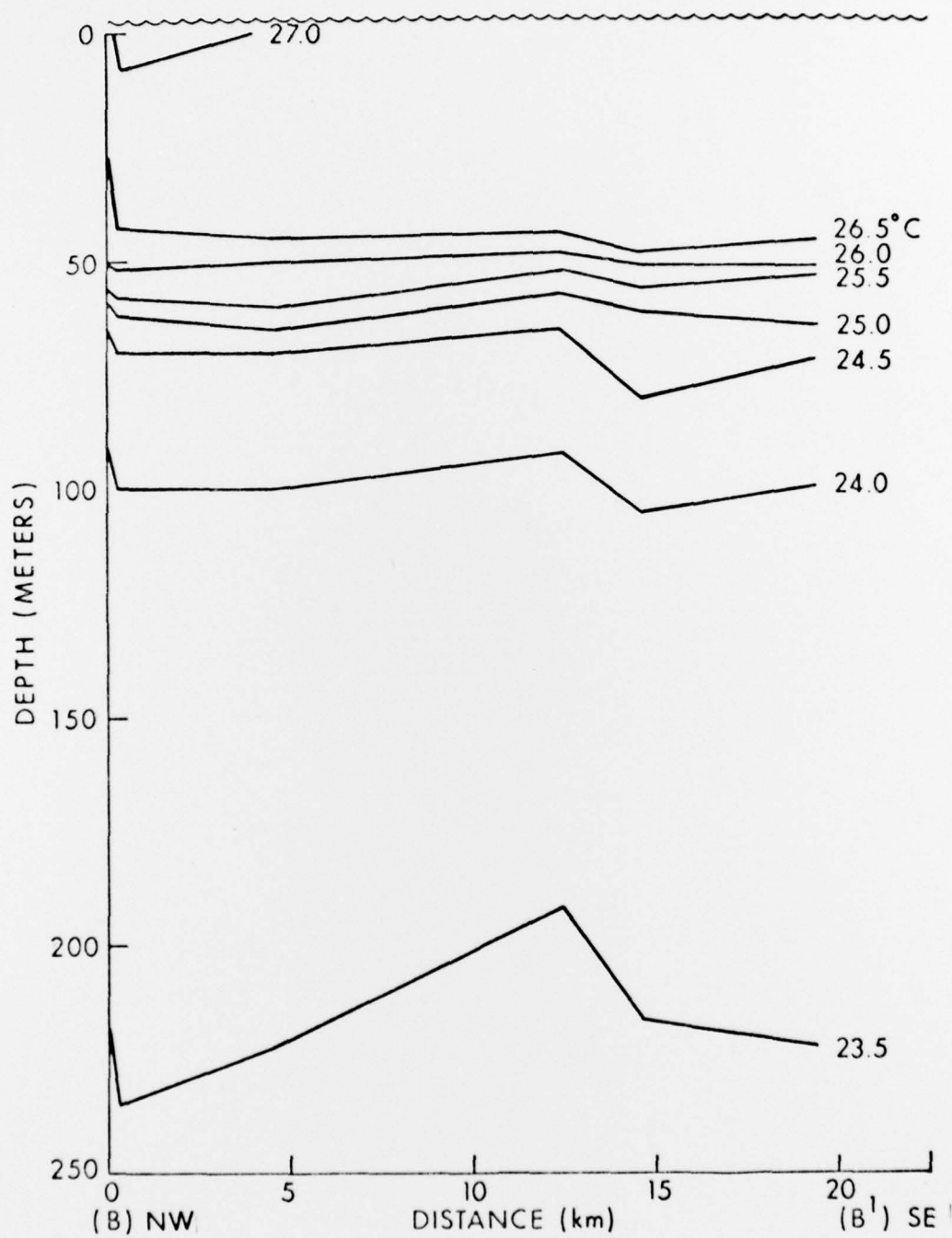


Fig. 8 - Cross-sectional Isotherms.

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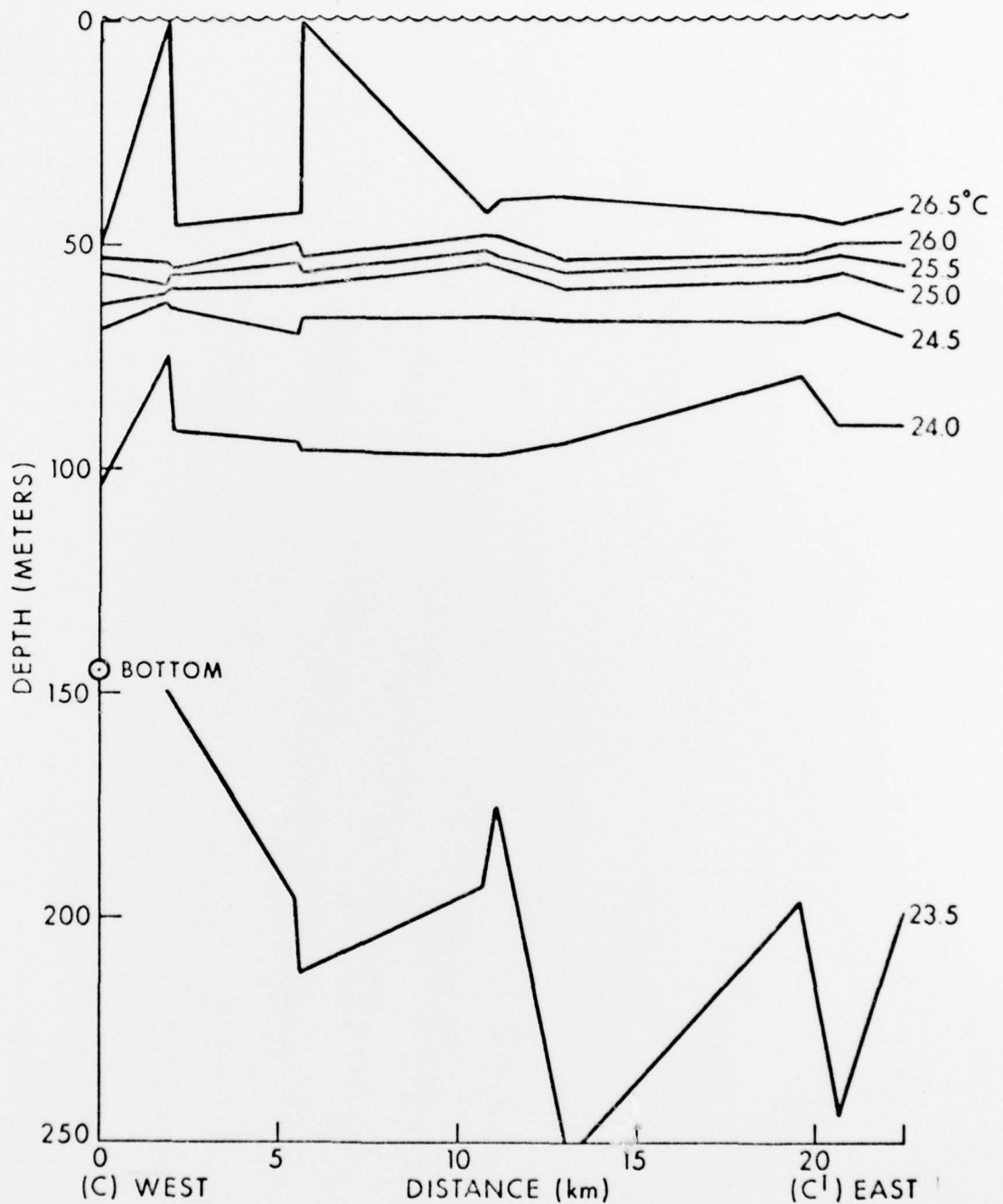


Fig. 9 - Cross-sectional Isotherms.

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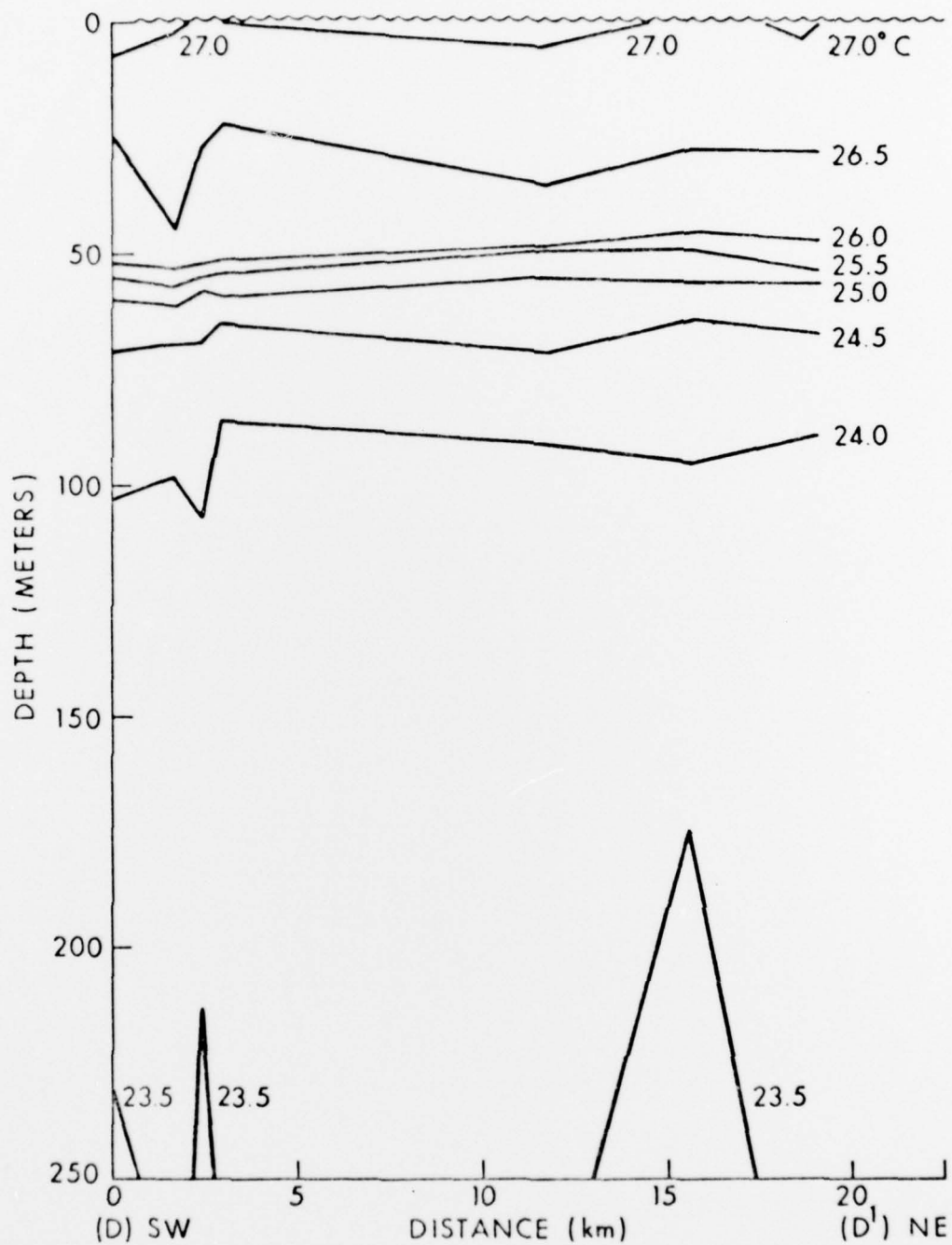


Fig. 10 - Cross-sectional Isotherms.

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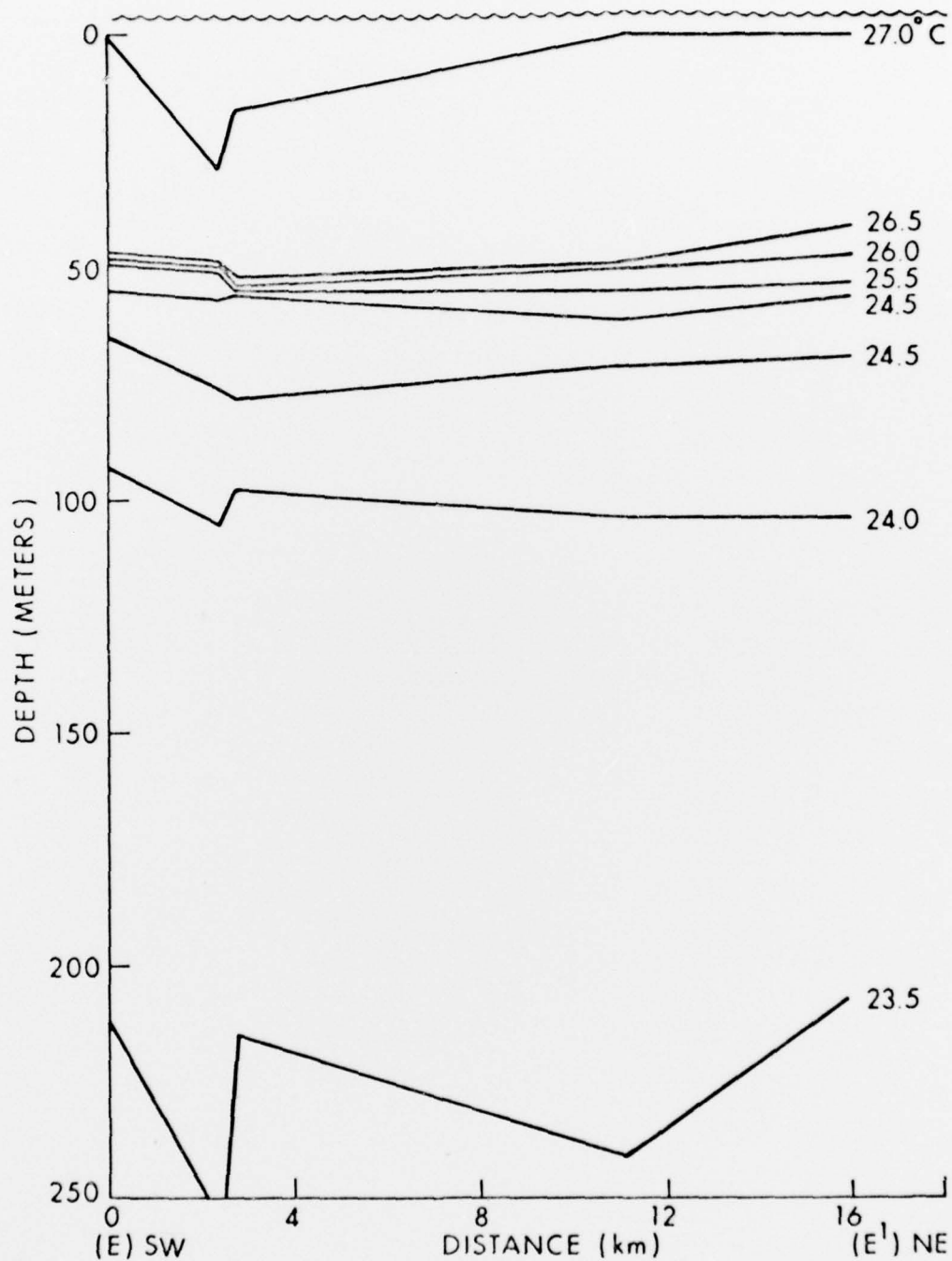


Fig. 11 - Cross-sectional Isotherms.

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